Department of Computer Science

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Computational Art – Robotic Picture Weaving

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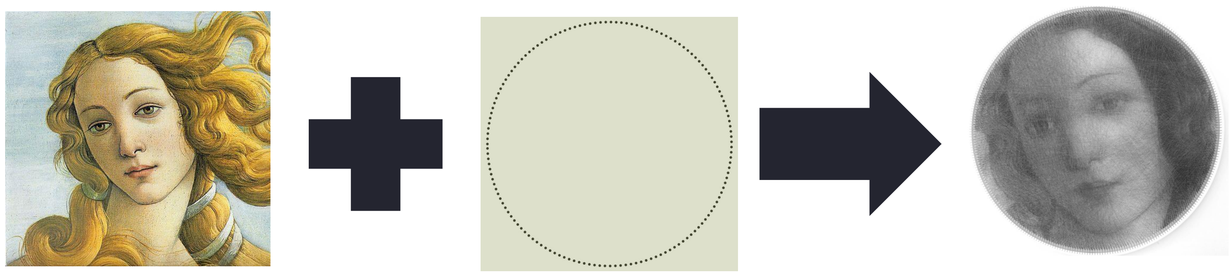
1. Background and Motivation

In recent years it became more common to incorporate computers in the artistic process. For example, image-weaving is a complex task, even for an experienced artist. Our project aspires to automate this process with the help of computer vision, graphics, and robotics.

2. Task description

Given a grayscale image, approximate it by drawing a continuous sequence of threads across an arbitrary convex frame of nails. Then, weave it using a robotic arm.



3. Approach and Concepts

Given two pixels p, q (each representing a nail), define the **strand** $s(p,q)$ as the set of pixels that resides on the chord between p and q.

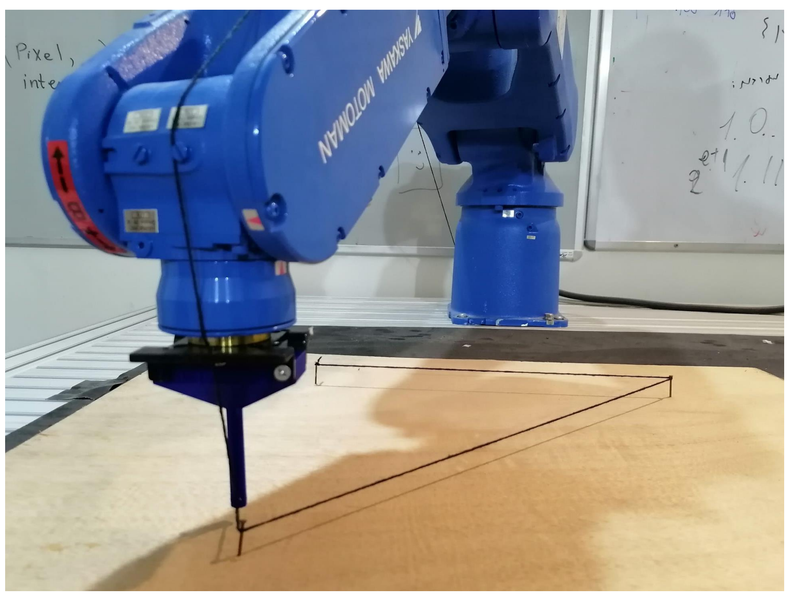
The crux of the problem is finding $S = (s_i)_{i=1}^{n}$, the sequence of consecutive strands that best approximates the original image when woven across the nail frame. A greedy approach of always picking the strand with minimal mean value was found to yield the best results. formally, we pick the strand $s(p,q^*)$ such that p is the current nail and:

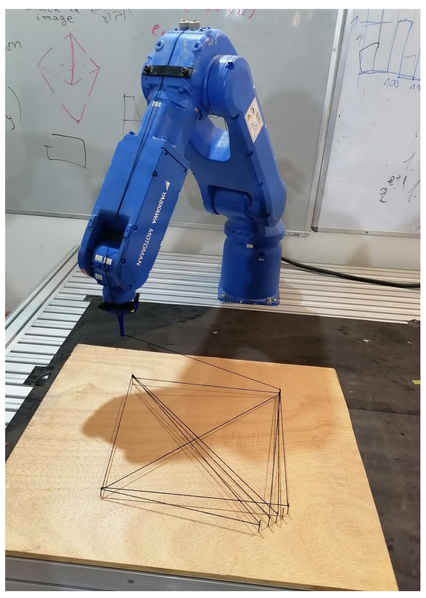
$$q^* = \underset{q \in \mathcal{N}}{\operatorname{argmin}} \frac{1}{|s(p,q)|} \sum_{(i,j) \in s(p,q)} [I]_{i,j}$$

where $\mathcal{N}$ is the set of all nails in the frame.

Every iteration, brighten the strand's pixels in the image by a constant t and halt when the darkest strand has a mean of α.

6. Coming Up Soon: Robotic Implementation





4. Algorithm and Workflow

Step 1 – Preprocessing
Adjust the image to fit the nail frame and calculate the nail positions from a picture of the board.

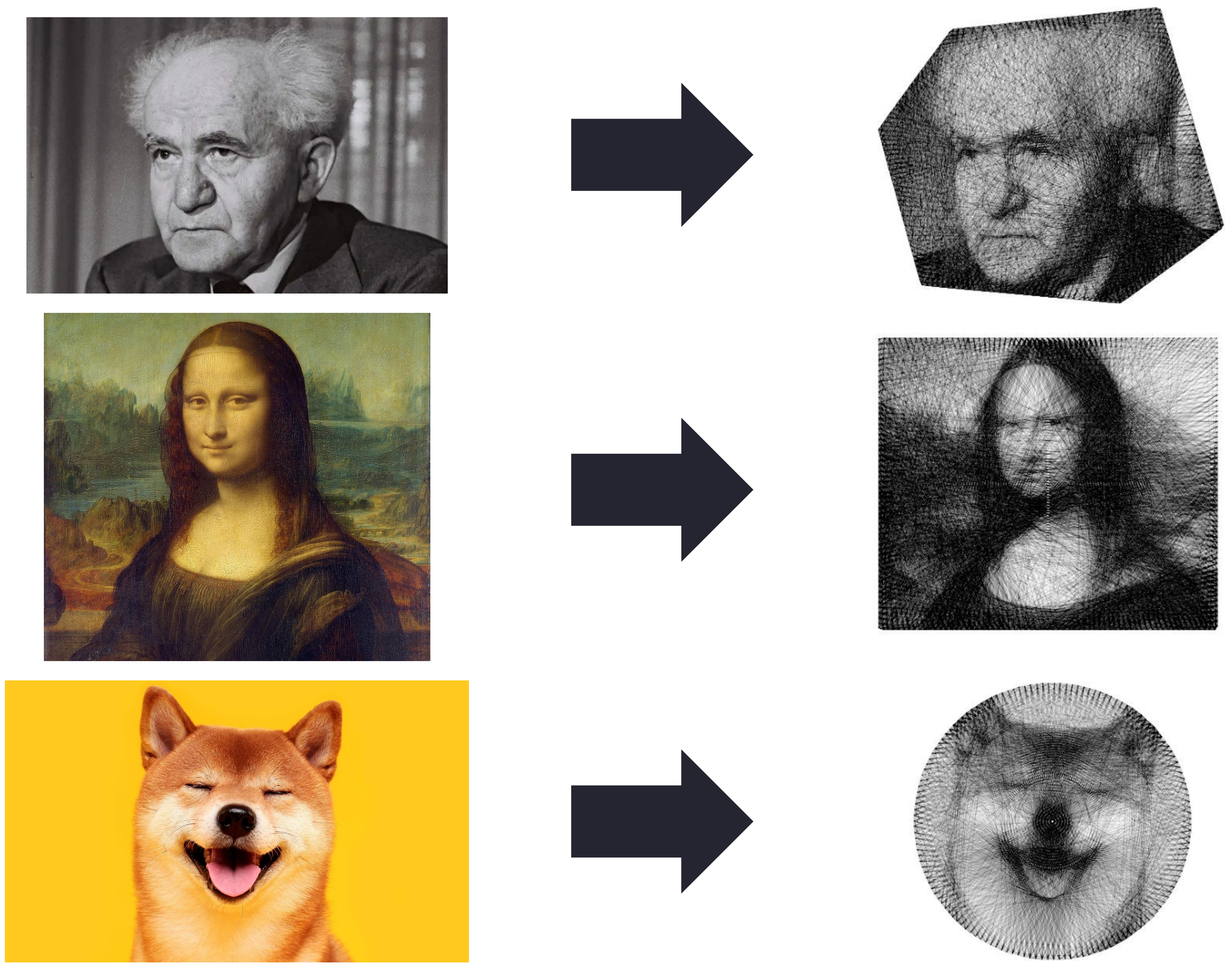
Step 2 – Strand Sequence Algorithm

```
StrandSequence(Image, Nails, t, alpha):
1: Sequence ← ().
2: Choose some arbitrary initial nail p.
3: do {
4:    s ← darkestStrand(p, Nails, Image).
5:    Image[s] ← Image[s] + t.
6:    Sequence.append(s).
7:    p ← s.otherNail(p).
8: }
9: while (mean(s) < alpha).
10: return Sequence.
```

Step 3 – Visual Assessment
Asses the algorithm's output visually, by simulating the weaving process with an animation, and plotting the expected result.

Step 4 – Weaving
Weave the generated approximation of the original image on the physical board using a robotic arm.

5. Results



Most of the robot's instruction code is ready to use. Yet, some fine-tuning is still needed before it will be able to perform its complex task; especially when handling delicate movements such as maneuvering between nails. In the upcoming weeks we plan to attain first results of a fully-automated artwork.